Rip Currents

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Award # N00014-97-1-0789

LONG TERM GOAL

To examine the dynamics of rip currents and the factors governing the evolution and magnitude of the cross-shore fluxes of sediment and water associated with rip cell circulation on a medium to high energy beach over a wide range of space and time scales.

OBJECTIVES

Scientific

❑ To examine the spatial and temporal variability of rip currents using remote video imaging techniques.

❑ To quantify changes in nearshore circulation and topography in response to varying incident wave conditions at different time scales including;

- ❍ wave groupiness (time scales of 1-10 minutes),
- ❍ tidal modulation (time scales of 12h and 24 h) and
- ❍ wave height fluctuations associated with passing weather systems (time scales of 2-5 days).

❑ To develop a coupled hydrodynamic and sediment transport model to simulate the coupling between the nearshore circulation forced by the incident wave field, and the nearshore topography.

Technical

❑ To advance current nearshore video imaging techniques using a high resolution digital camera system.

APPROACH

Video techniques can be used in three possible ways in our studies;

(i) In principle the video images can be used to build up a statistical description of rip cells including longshore and cross-shore length scales, persistence, surf zone width and some incident wave information (period and direction). It remains to develop an automated approach to obtaining some of these rip cell statistics.

(ii) Fluctuations of the head can be measured through video time stacks and should provide a good proxy for the fluctuating strength of the rip current. Preliminary results using 15 minute time sequences of shorter time exposures (of order one minute) have shown at least one example in which the entire rip head can be observed to expand offshore.

(iii) It may be possible to use the offshore advection of foam (or other visible features) to estimate actual rip current velocities. A similar approach, based on time stacks, for the estimation of longshore current velocities appears quite promising. Testing of this approach is a research goal of this work.

We also aim to combine the video images with numerical simulations to investigate the spatial and temporal variability of rip currents in response to changing incident wave conditions and sea level fluctuations. For example, tidal modulation of rip currents has been discussed by Shepard et al (1941), Sonu (1972) and Short and Hogan (1994). Theoretical considerations suggest the magnitude of onshore flow over the bar due to wave pumping depends on the relative magnitudes of incident wave height and depth over the bar which in turn varies with tidal elevation. We will examine tidal modulation of currents and setup numerically, while variability in rip current intensity may be quantified using the video techniques outlined above.

WORK COMPLETED

In January 1998, Holman visited the Australian Defence Force Academy and the Palm Beach Argus station was upgraded with colour cameras and an SGI workstation (see figure 1). Roshanka Ranasinghe was appointed to a post doctoral position and commenced on April 1st, 1998. Both Symonds and Ranasinghe attended the 2nd Argus Workshop, July 20-24, as part of extended visits to Oregon State University - Ranasinghe, July 17 to August 8 and Symonds, July 17 to October 15. A summary of the exchange visits is shown in Table 1.

Name	Institution	Position	From	To	Dates
Robert Holman	Oregon State University	Professor	Oregon State University	ADFA/Sydney	Jan 28 - Feb 1 1998
Graham Symonds	Australian Defence Force Academy	Senior lecturer	ADFA	Oregon State University	July 17 - Oct 15 1998
Roshanka Ranasinghe	Australian Defence Force Academy	Post doctoral fellow	ADFA	Oregon State University	July 17 - Aug 8 1998

Table 1 Personnel exchanges

From two years of video images we have extracted daily time series of mean surf zone width and longshore profiles of intensity averaged across the surf zone. The shoreline and breakpoint were identified using gradients in intensity. These data are being used to (a) classify beach state and (b) examine the formation and evolution of rip channels. Rip channels typically appear as intensity minima in the longshore profiles and the mean spacing has been determined using two techniques. Firstly, for the case of uniformly spaced channels the autocorrelation of the longshore intensity profile has a peak at a lag corresponding to the mean rip spacing. Secondly, a zero upcrossing analysis of the longshore intensity profiles has been used to identify the location of individual rip channels. These data have then been used to estimate the mean and standard deviation of rip spacing. In this second case the analysis is not restricted to uniformly spaced rip channels. The cross correlation between daily longshore intensity profiles has been used to examine the persistence of rip channels.

A numerical model for rip current generation on a plane beach has been developed and preliminary results are encouraging. A particular feature of the model results is the predicted rip spacing is of order 100's of metres consistent with the video results from Palm Beach and other observations from medium to high energy, swell dominated natural beaches. During the recent visit to OSU we began a numerical study of rip currents on a barred beach with pre-existing rip channels. The aim of this work is to examine the factors governing rip current intensity, such as incident wave forcing and nearshore bathymetry.

RESULTS

Beach classification

Palm Beach generally conforms to the beach state model described by Wright and Short (1984). Following high wave events the beach typically exhibits Longshore Bar Trough (LBT) morphology and, during subsequent periods of decreasing wave height transitions to Rythmic Bar and Beach (RBB),

Figure 1 Time exposure images from the new colour camera installed in January 1998. The left panel shows the Longshore Bar-Trough morphology while the right panel shows Transverse Bar and Rip morphology as defined by Wright and Short (1984).

Transverse Bar and Rip (TBR) and Low Tide Terrace (LTT) are observed. Examples of Longshore Bar-Trough and Tranverse Bar and Rip morphology are shown in Figure 1. Rip currents are a dominant feature of these beach states, particularly the RBB and TBR states, and as such play an important role in the mean flow and sediment transport associated with the morphological evolution. Using the parameters extracted from the video images we aim to obtain a more continuous measure of beach state which might then be related to incident wave conditions.

Rip Evolution

Using the zero upcrossing analysis of the daily longshore intensity profiles for a two year period the mean and standard deviation of rip spacing on Palm Beach are 193m and 71m respectively. The auto-correlation analysis gave a mean of 229m and standard deviation of 66m. In the latter, estimates of rip spacing are only obtained for uniformly spaced rips when the autocorrelation is statistically significant at the 95% level. Using the longshore intensity profiles we can also estimate time series of rip channel locations (from the intensity minima) and an example is shown in Figure 2. These data clearly show the rip channels migrating alongshore towards the north. While the rip channels do not normally persist for extended periods as shown in Figure 2, evidence of migrating rip channels over shorter periods are common throughout the two years of data analysed to date. We are currently investigating whether longshore currents driven by obliquely incident waves may account for the migration which is observed to occur both northwards and southwards.

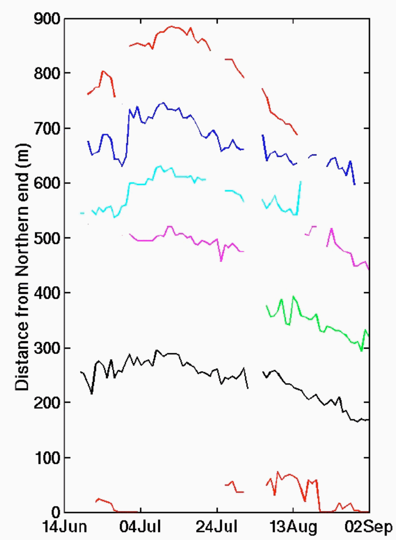

Figure 2 Rip location determined from a zero upcrossing analysis of longshore intensity profiles extracted from the time exposure video images. The mean trend between July 4 to September 2 represents a northward migration of the rip channels at a rate of 4m/day.

Modelling

Bowen (1969) described a model for generating uniformly spaced rip currents on a plane beach through the synchronous interaction between a monochromatic, normally incident wave field and an edge wave. The longshore length scale is determined by the wavelength of the edge wave. However, the wavelength of edge waves at incident wave frequencies are typically an order of magnitude smaller than the spacing observed on medium to high energy, swell dominated beaches. We have developed a linear model forced by incident wave groups synchronous with an edge wave at the group frequency. The rip spacing is again determined by the wavelength of the edge wave but the lower group frequency produces longshore scales of 100's of metres. An example of the solutions for a group frequency of .01cps is shown in Figure 3 where the longshore spacing is of order 500m. Rip currents result from longshore variations in the minimum and maximum breakpoint positions and, consequently are confined to the outer region of the surf zone as shown in Figure 3.

Further numerical work is being undertaken to examine rip circulation on a barred beach with pre-existing rip channels. In this case, rips are produced by longshore variations in topography and the intensity of the flow is a function of the bar-channel geometry and incident wave forcing. Non-linear effects are also included causing the rips to become narrower and extend further offshore.

IMPACT/APPLICATIONS

The recent increase in focus on the littoral environment has pointed out weaknesses in our understanding of nearshore dynamics. While our knowledge of nearshore fluid motions on simple topography has become quite good, such simple cases are actually rare. Most often beaches are three-dimensional leading to longshore and cross-shore variations in wave heights and associated mean flows. The development and evolution of such systems has only been poorly sampled. This work takes

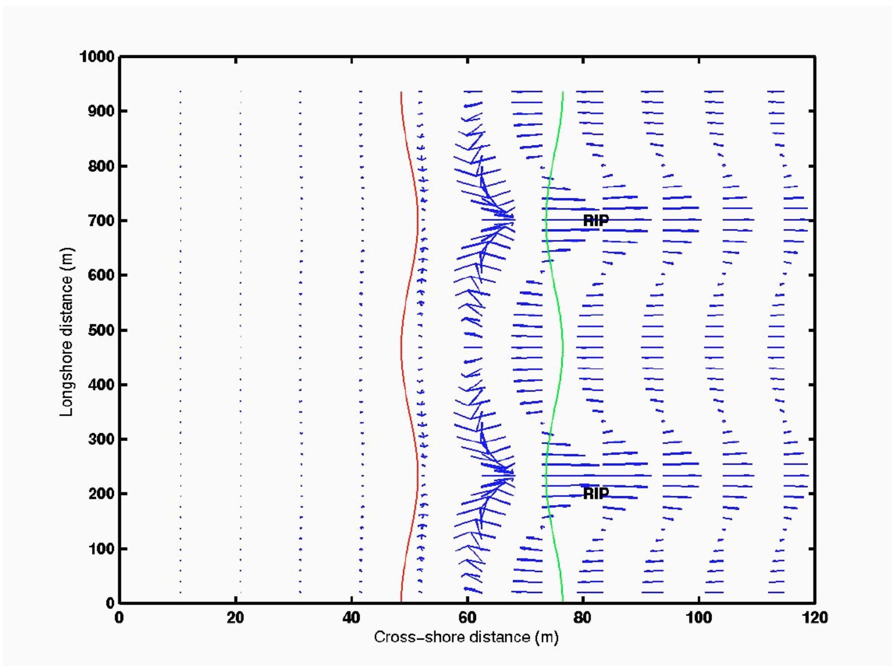

Figure 3 Rip current generation on a plane beach through the synchronous interaction of incident wave groups and an edge wave at the same frequency. The red and green lines represent the minimum and maximum positions of the breakpoint respectively.

advantage of a strong combination of low-cost, data-rich sampling of the Argus program, mixed with modelling skills, to help advance understanding of these ubiquitous fluid/sediment interactions.

The result of this work will help provide environmental understanding of important mean current and topographic variability that is likely to be encountered on natural beaches. This type of understanding is needed for all amphibious operations in nearshore waters on sandy coasts.

TRANSITIONS

RELATED PROJECTS

Interstitial flow through beach sands, G.Symonds and I.T.Webster. This project aims to measure water table fluctuations and interstitial flow in the swash zone utilising the digital camera to monitor the wetting front and in situ measurements of pressure and flow within the sediment.

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PUBLICATIONS

Symonds,G., Holman,B., and Bruno,B., 1998. Rip Currents, Proc. Coastal Dynamics ‘97, E.B. Thornton (ed), Plymouth, U.K., ASCE, 584-593.